WP4: Camera Test & Evaluation System

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Lead: MKD
Participants: PMC, Liv-PDRA, Durham technician, + PhD students

Durham University

WP4: Camera Test & Evaluation System

Requirements: self-monitoring system producing 3-4ns FWHM light pulses from 0.1pe to at least 1000pe.

Solution: use an array of LEDs gives dynamic-range/linearity measurements, spectral response could be tested with LEDs of different colours.

WP4.1: System Design (yr/qtr 1/1)

Determine optimum geometry of system wrt position on telescope structure. Selection of necessary optical components (diffuser, filters, etc).

WP4.2: LED driver circuit development (yr/qtr 1/2-1/3)

Selection of LEDs and choose between candidate design types to produce fast, bright pulses.

WP4.3: Control & Monitoring System and Enclosure (yr/qtr 1/4-2/1)

Integration into array control, interface to telescope structure, power and control requirements. Selection of weather proof enclosure to IP66 or IP67 standard

WP4.4: Assembly & Testing (yr/qtr 2/1-2/2)

Lifecycle and environment testing. Ability to reproduce calibration information for PMTs with well understood characteristics.

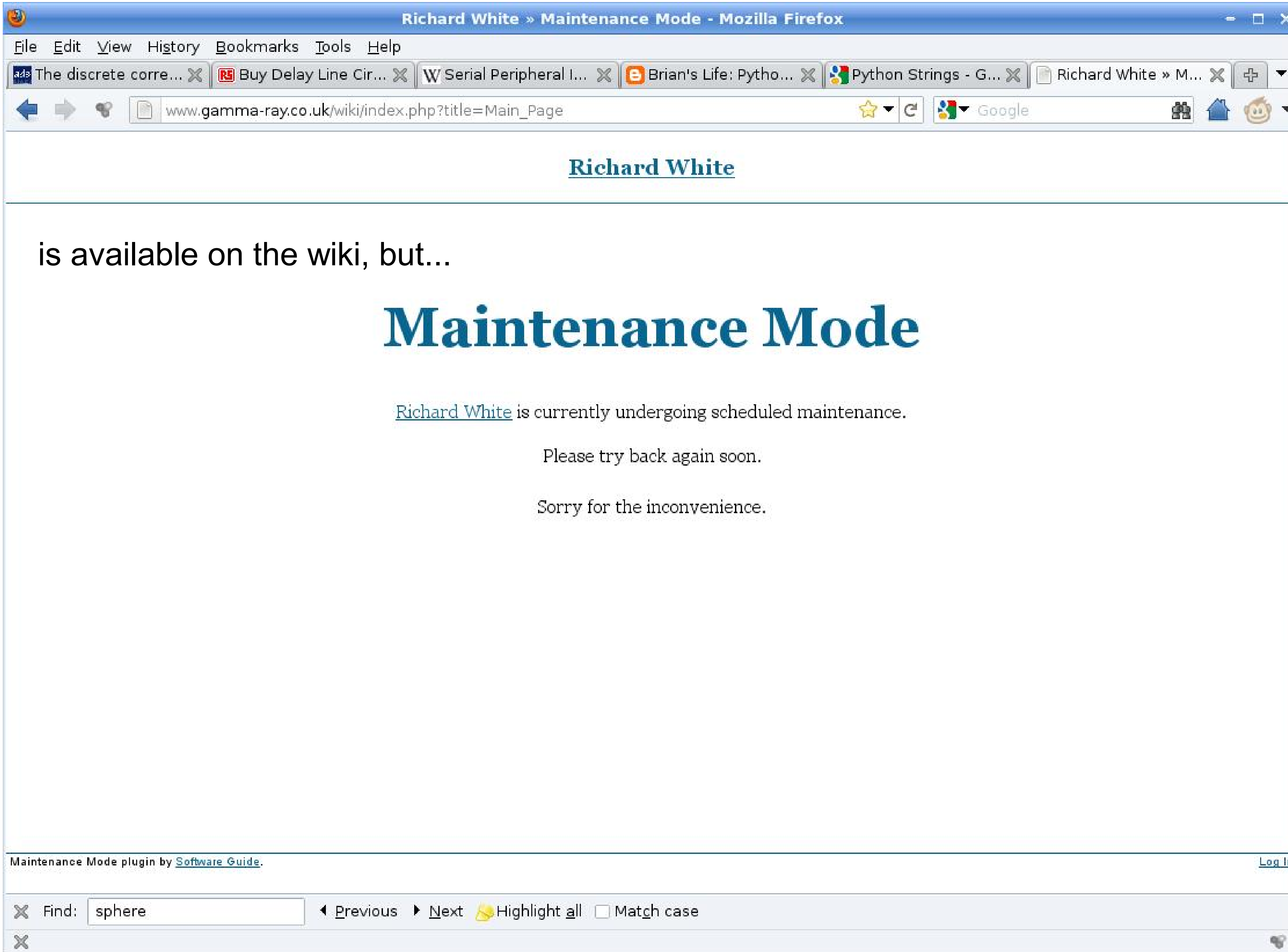
delivery to Leicester by end of month 16

WP4 Schedule

Calibration system requirement document -
start:April 2012; end:July 2012; done: May 2012
Calibration system optical design -
start: April 2012; end: Aug 2012;
Calibration system mechanical and operational concept -
start: Jun 2012; end: Aug 2012;
Calibration system test plan -
start: Jul 2012; end: Oct 2012
LED driver circuit design -
start: Jul 2012; end: Dec 2012
Lab calibration system -
start: Nov 2012; end: May 2013
Lab calibration system test report -
start: May 2013; end: June 2013
Field calibration system design -
start: Nov 2012; end: Jul 2013
Field calibration system -
start: Jul 2013; end: Apr 2014
Field calibration system test report -
start: Apr 2014; end: May 2014?
Field calibration system in-field test report -
end: ?

Calibration system requirement document

is available on the wiki, but...



CHEC calibration system requirements

* The calibration system will produce a fast light pulse
* The calibration system will produce a well understood/uniform light pulse.
* The calibration system will produce a light pulse at a wavelength range close to the peak of the Cherenkov spectrum.
* The calibration system will produce a light pulse for flat-fielding the camera pixels.
* The calibration system will produce a light pulse for determining the adc/pe ratio of the pixel chain.
* The calibration system will produce a light pulse to determine the linearity of the system.
* The calibration system will trigger from camera commands.
* The calibration system will be capable of generating internal trigger signals (?)
* The calibration system will transmit housekeeping information to the camera.
* The calibration system will operate in specified operational modes: standalone, observation (ie the calibration system will inject events into normal observing modes)
* The calibration system will operate in a temperature range of -10 to +30C
* The calibration system will be able to monitor the light level of flashes
* The calibration system will produce an output pulse at a fixed time with respect to the light flash

  * The light pulse must have a dynamic range of 0.1 to 1000 pe at the pixel (within full range of operating conditions).
    Impacts choice of light source, choice of diffuser, choice of filters, choice of location.
  * The shape/uniformity of the light front up to 4 degrees off axis must deviate from known/model to <=5% (CHECK). Impacts choice of diffuser, location of calibration box on telescope.
  * The light pulse must have a maximum FWHM of 6ns, with a goal of 4ns.
    Impacts choice of light source/choice of driver circuit.
  * The light source must be in the wavelength range of 330nm->420nm.
    Impacts choice of light source (and power supply to second order).
  * The system must operate at rates up to 10kHz (CHECK).
    Impacts choice of driver circuit & light source, Dependent on camera hardware & dacq.
  * The system must operate from a <=24V power supply.
  * The system should be able to be controlled via a serial link (protocol TBD).
  * The system must provide monitoring information on output light pulse.
  * The system must provide environmental conditions monitoring (temperature and perhaps humidity)
  * The system must be solar UV resistant, dust tight and resist spraying water (see level A specs)

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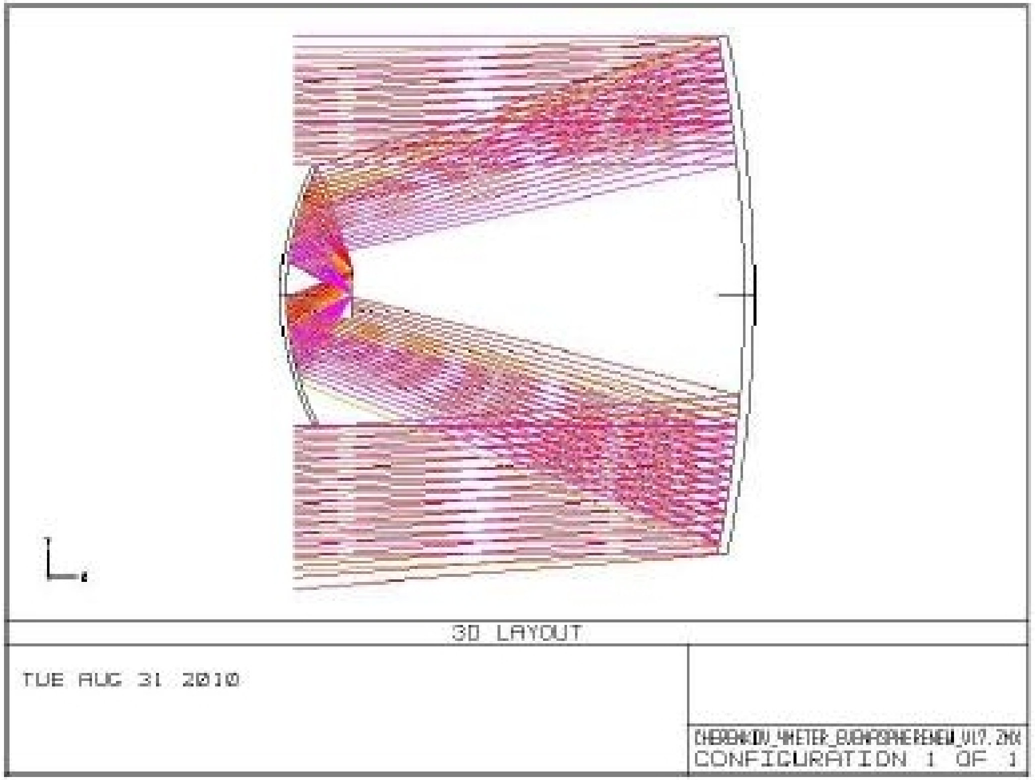
  end: ?

Calibration system optical design

Detector flatfielding options for the 4m dual mirror SST

Version 2.0, 2012-06-08

Jürgen Schmoll, CfAI Netpark, Durham University



WP4.1: System Design: Where to mount the light source? Reflect off secondary mirror.

The simulation shows that a numerical aperture of 0.25 (equivalent to an f/2 beam) is requried to fully illuminate the detector plane. The divergent f/2 beam transforms into roughly f/4 after hitting the concave secondary mirror. The beam tilts with respect to the optical axis is 7.2° at the edge of the focal plane, hence the tilts are much smaller than during operation.

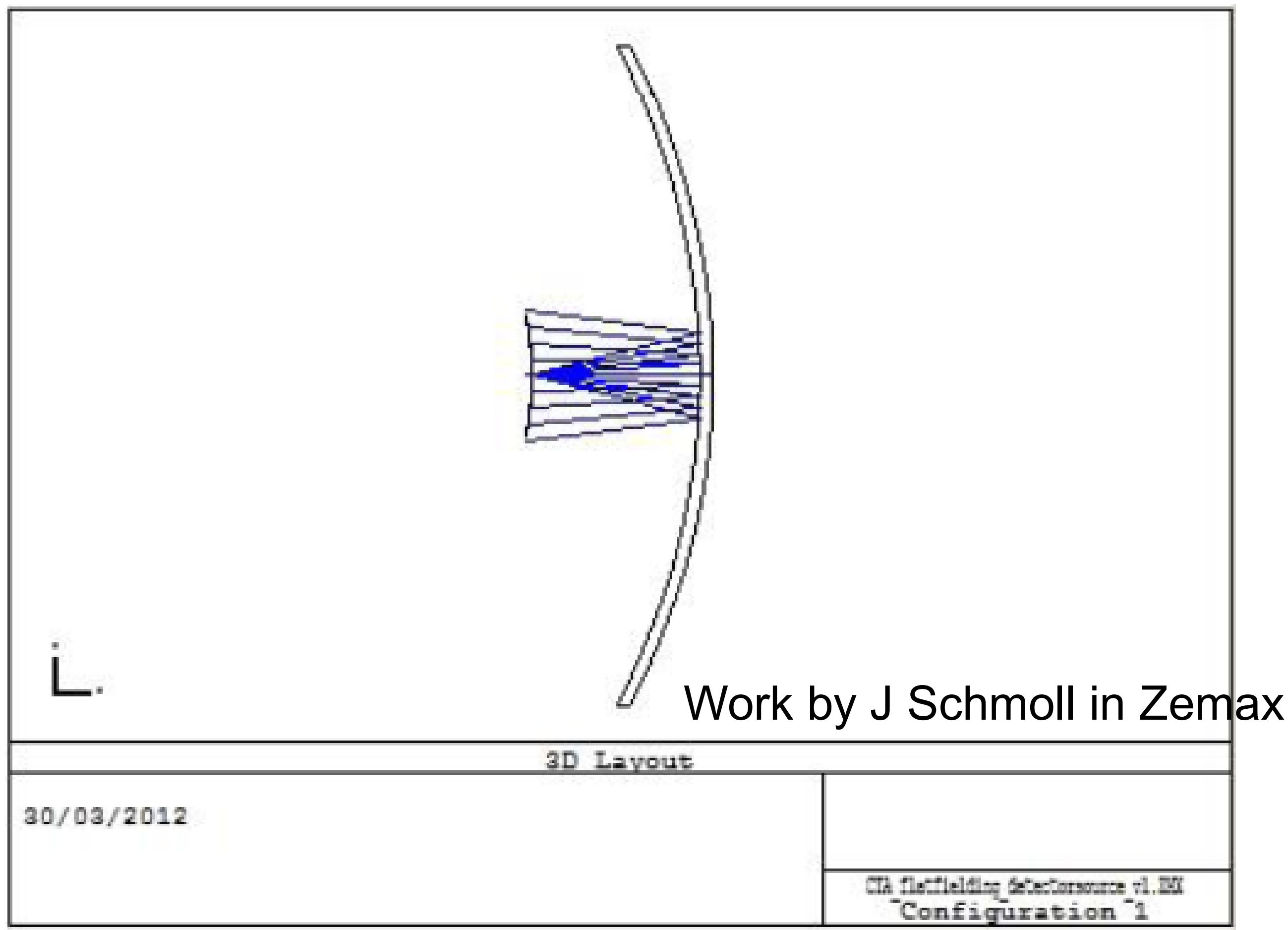


Figure 1: The indirect illumination of the focal plane by using a central portion of M2.

WP4.1: System Design: Where to mount the light source? Reflect off secondary mirror.

To work the secondary must be monolithic...

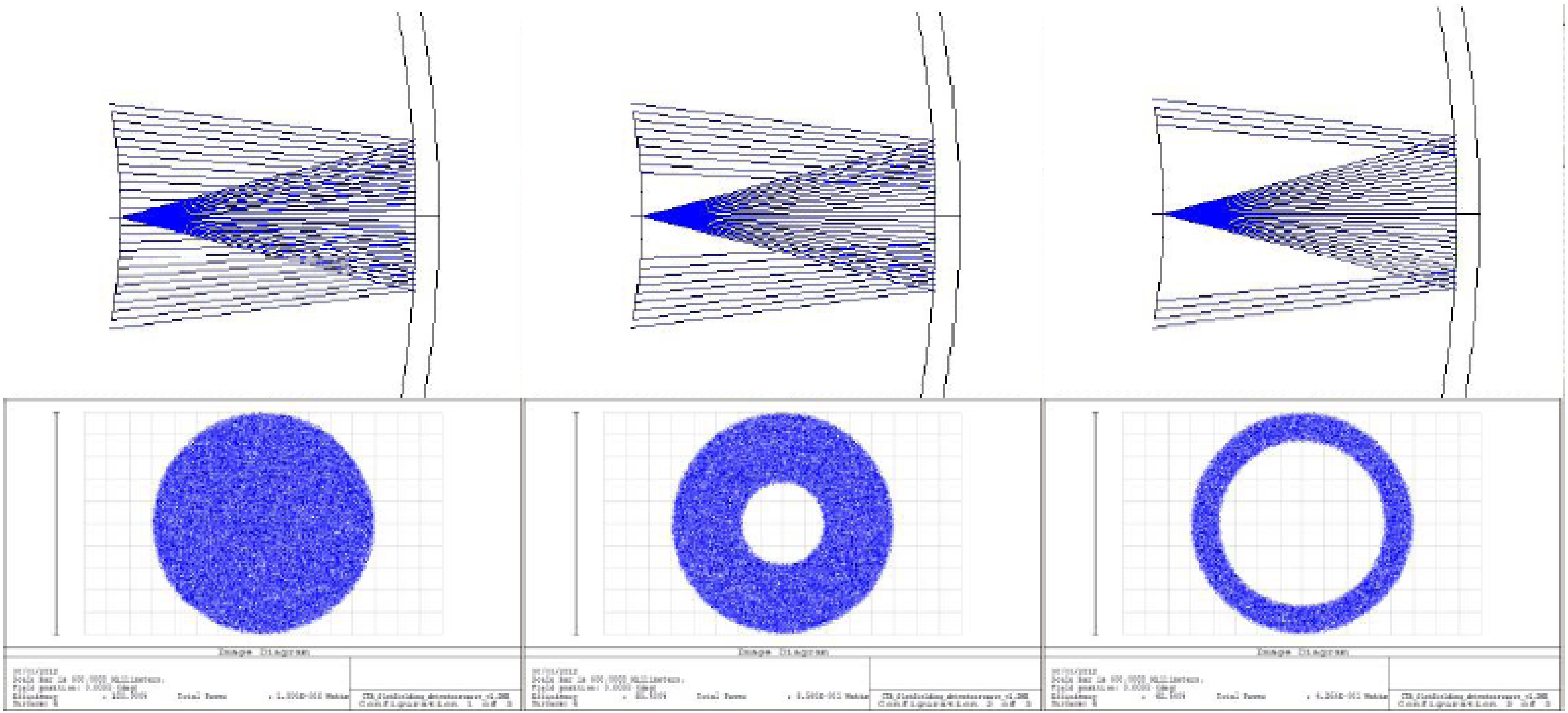
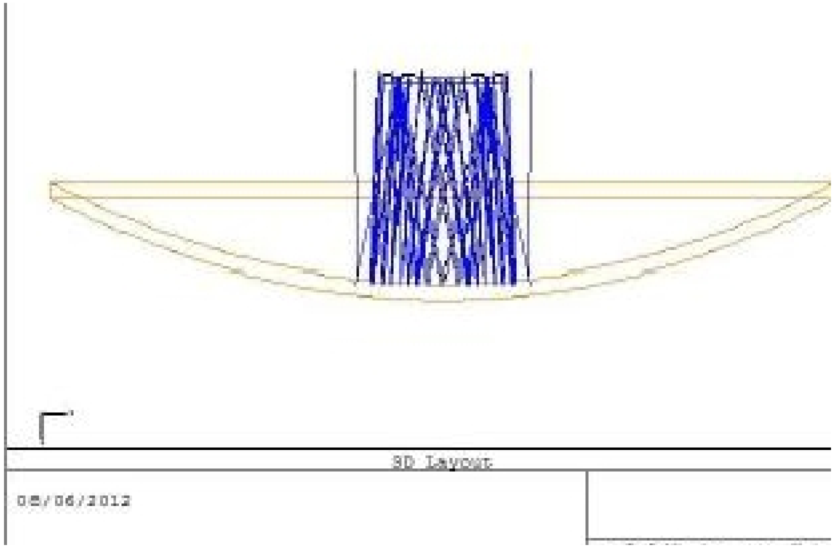
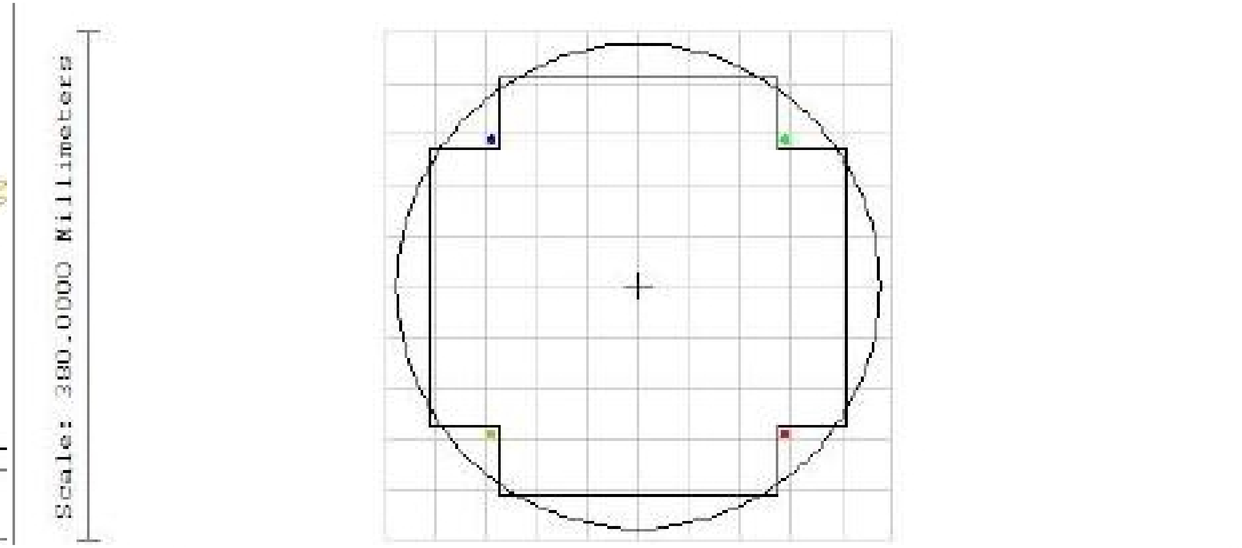


Figure 2: Effect of missing M2 centre on detector plane illumination. Top: Layout view, Bottom: Image simulation (400mm scale bar). M2 non-reflective central part diameters of 0mm (full M2, left), 50mm (centre) and 100mm (right).

Indirect off-axis illumination: various sources at the detector plane





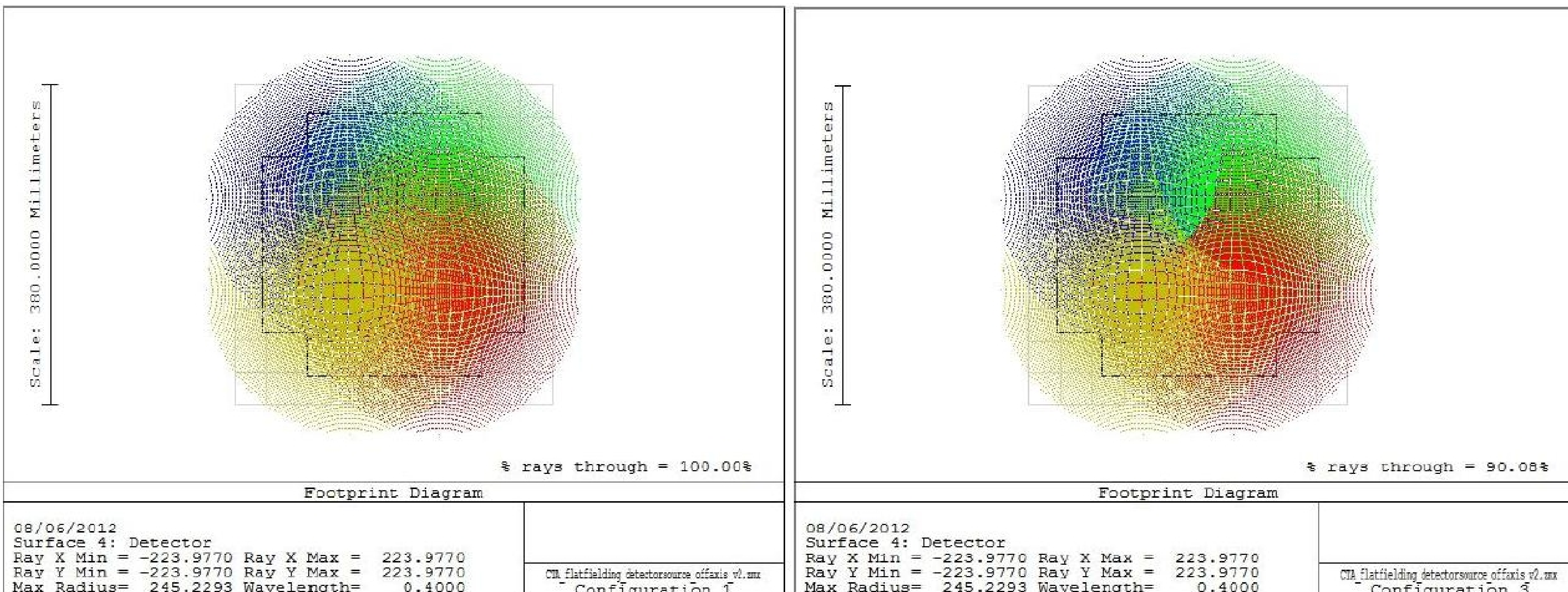
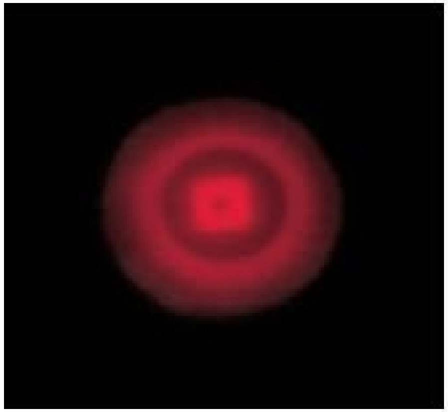
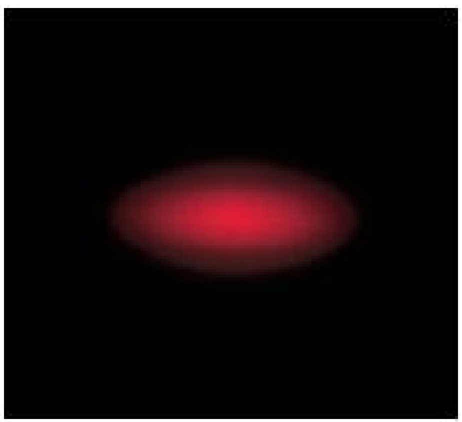


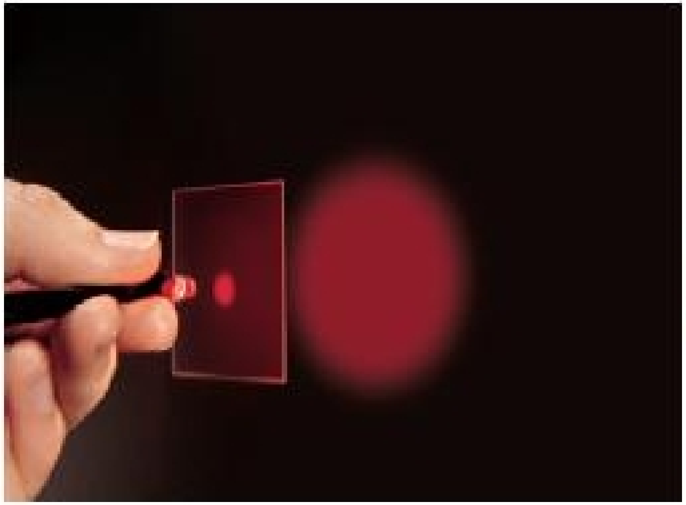
Figure 7: Footprint diagram of all four sources illuminating the detector plane. Left with complete M2, right with 100mm hole in M2 centre.

Diffusers

LED

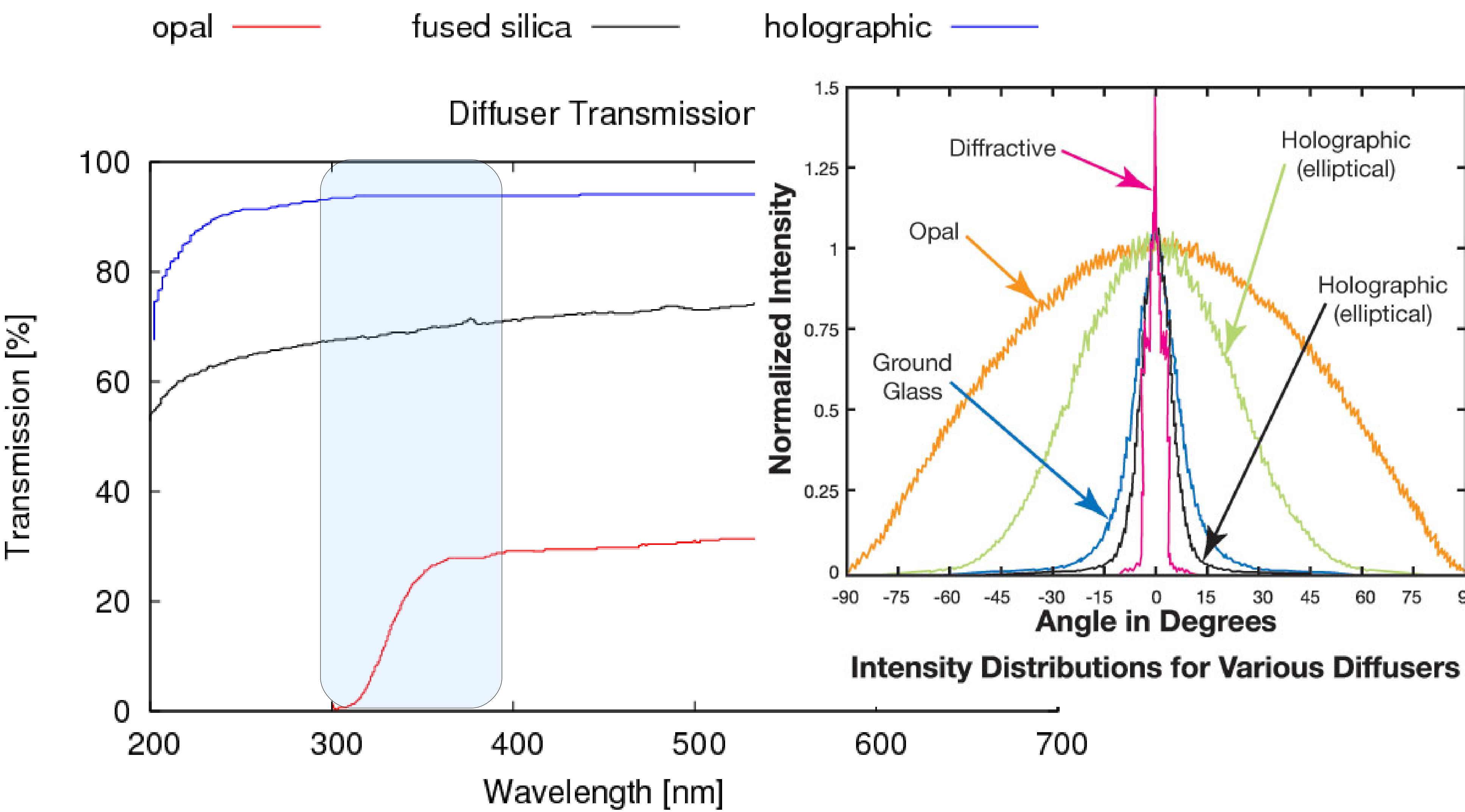






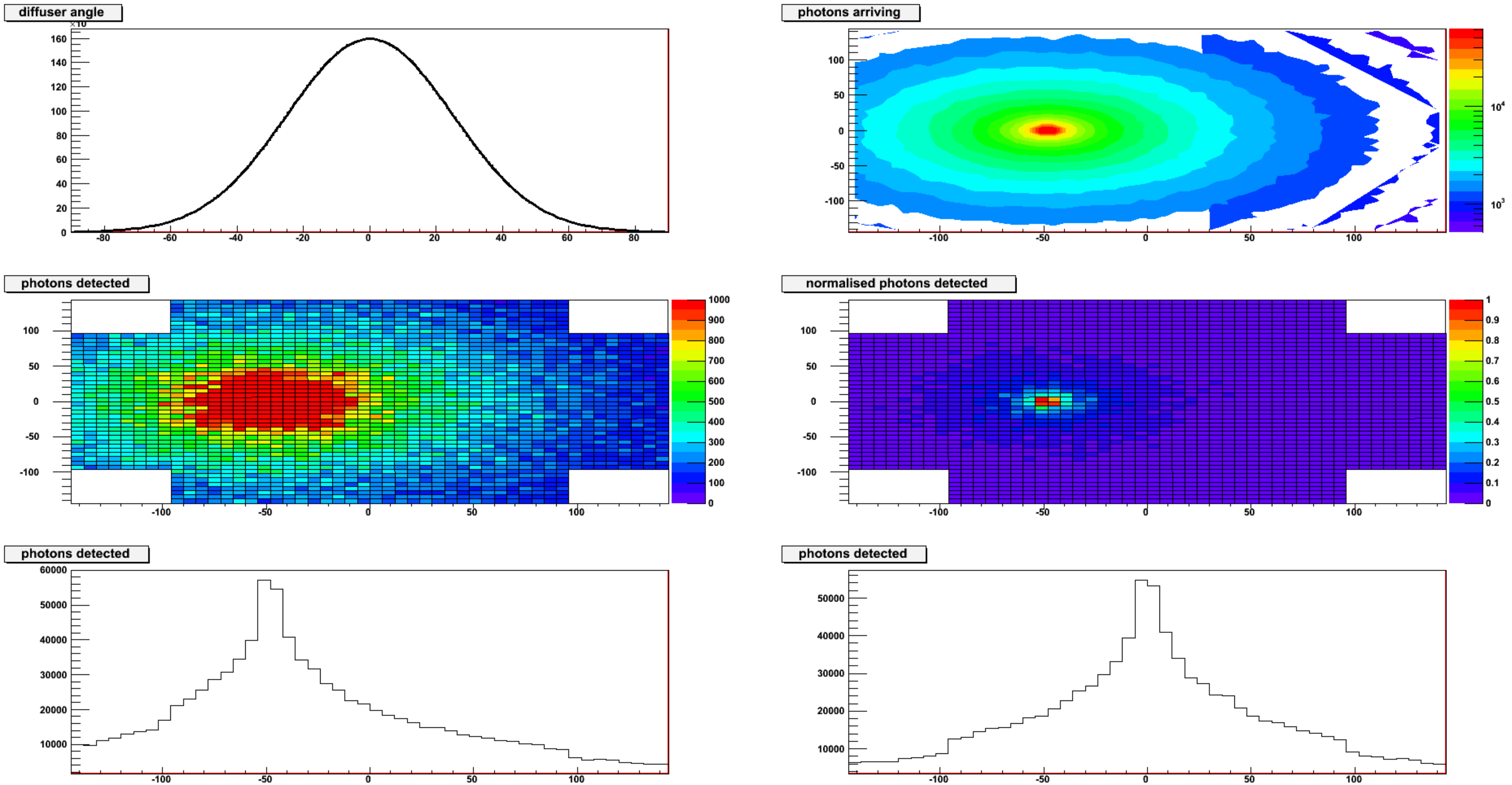
LED Source
20° FWHM Circular

Requirement: The uniformity/shape of the light front up to 4 degrees off axis must not deviate from known/modelled by >5% (CHECK).
Impacts: Impacts cost - choice of diffuser; location of calibration box on telescope.

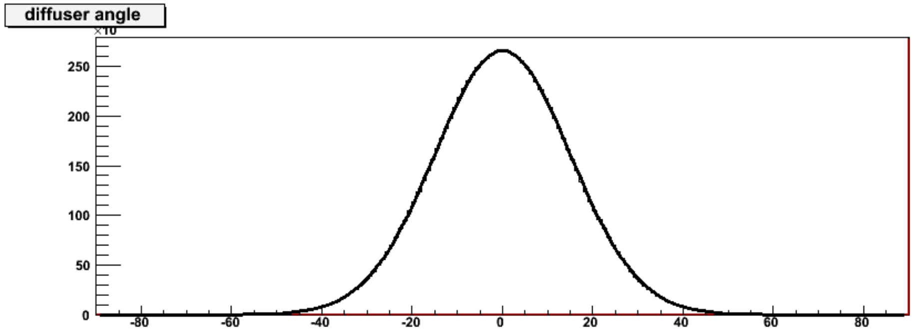


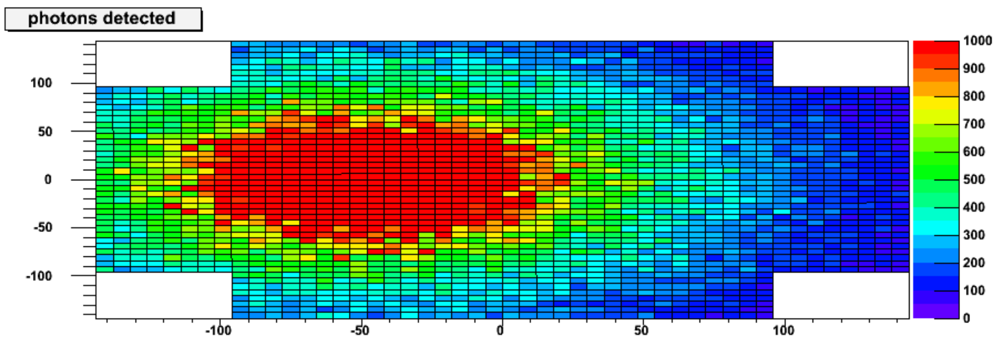
Opal diffuser is inexpensive, but highly attenuating and not ideal in the UV.
Holographic diffuser can be up to 30x cost of opal diffuser & conceivably ¼ cost of a €1000 calibration unit.
Fused silica light distribution is strongly peaked in the centre, making it difficult to integrate out.

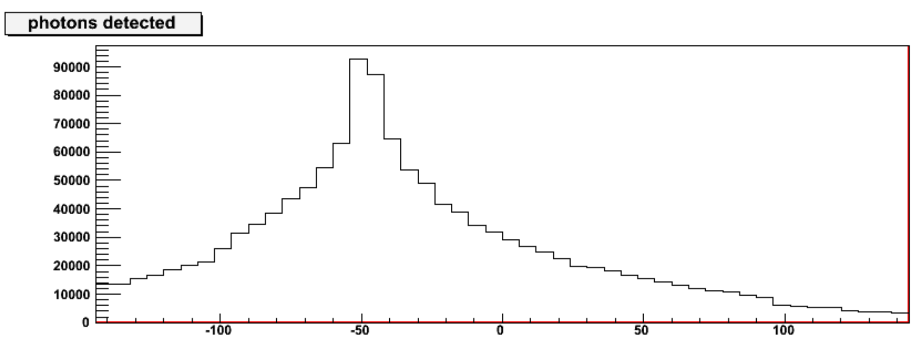
25 degrees, 1e7 photons



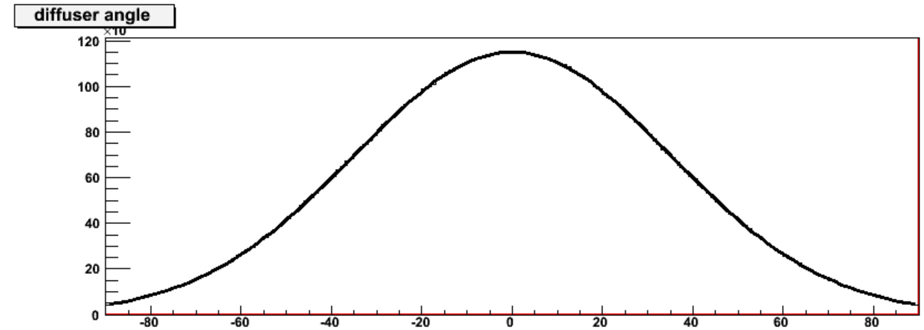
15 degrees

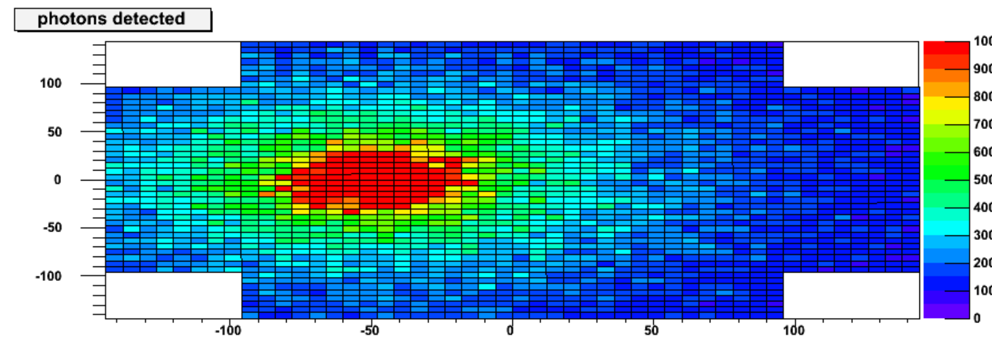


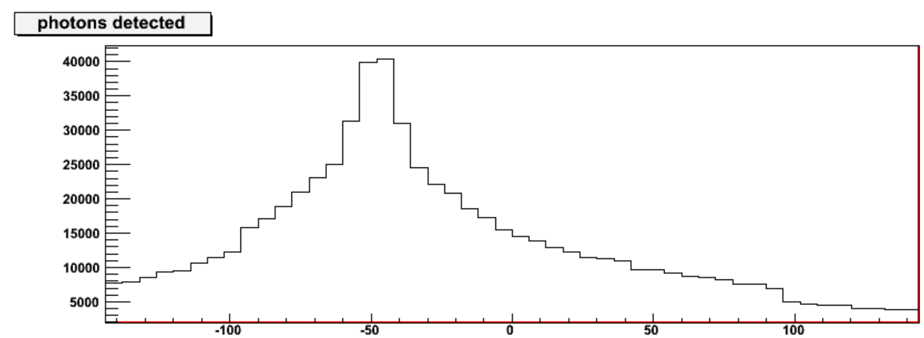


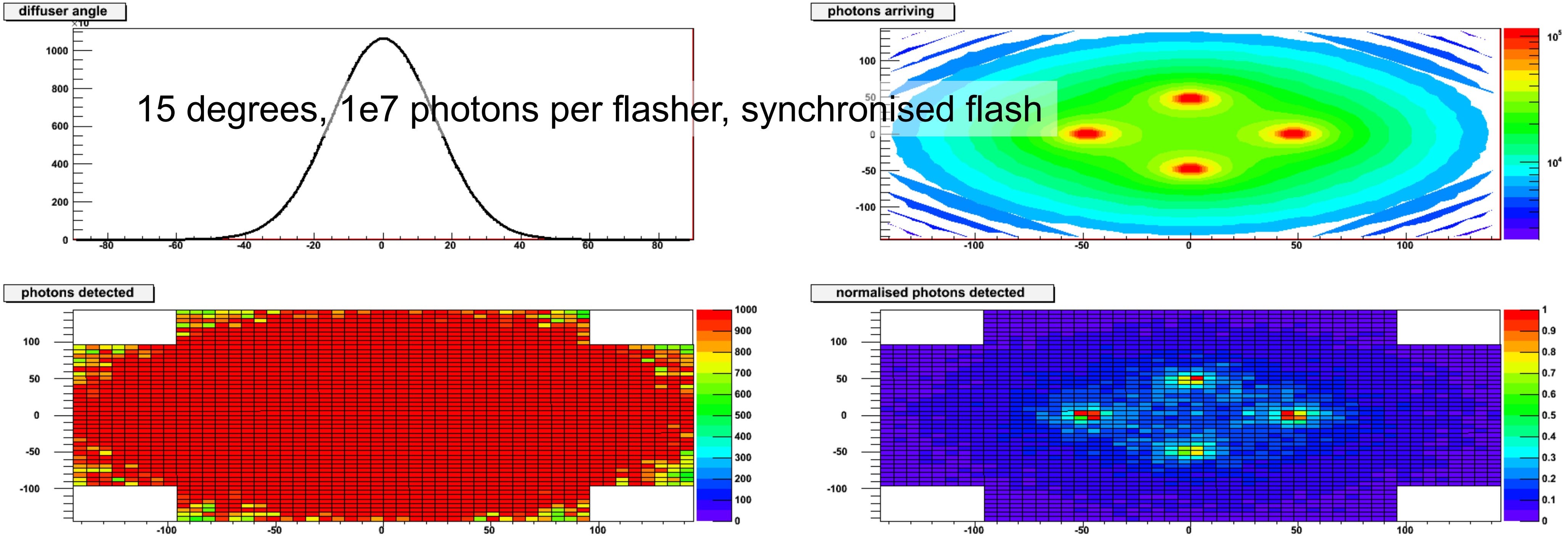


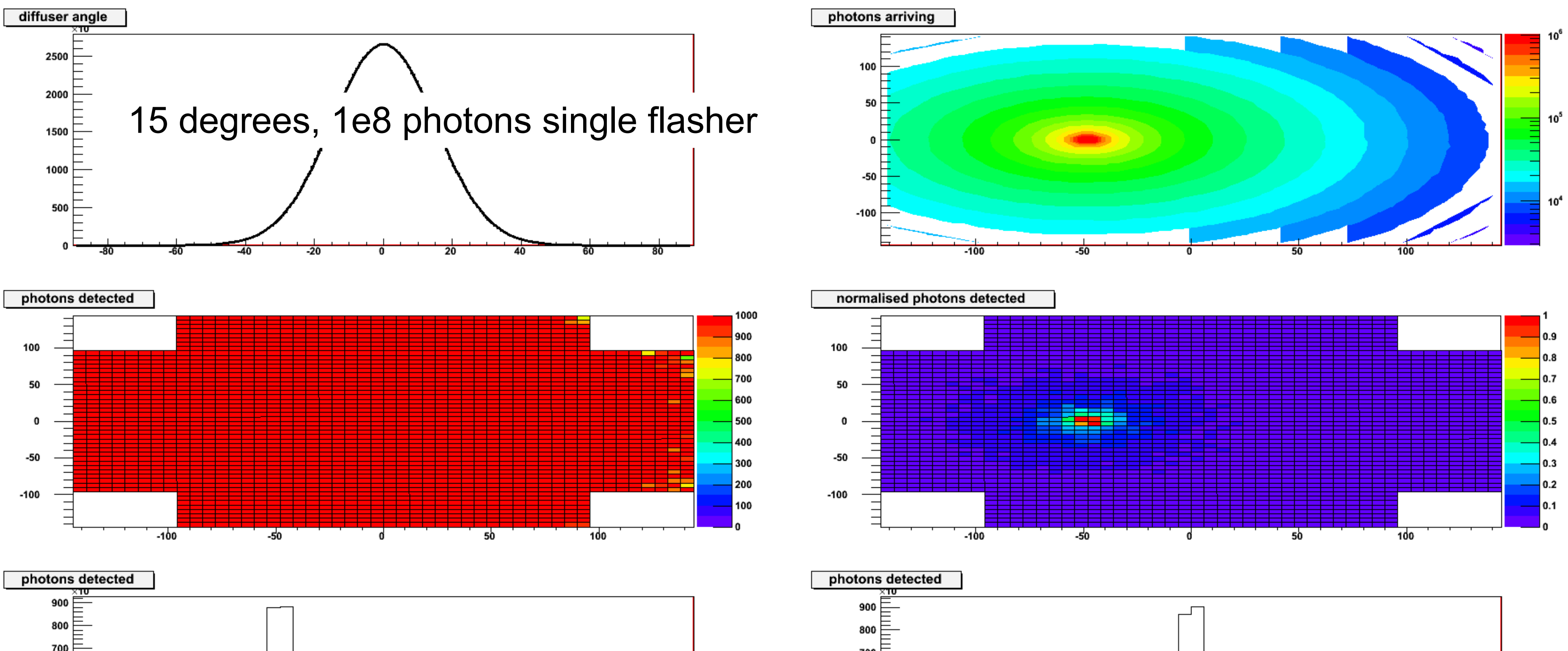
35 degrees








diffuser angle
photons arriving
15 degrees, 1e7 photons per flasher, synchronised flash
photons detected
normalised photons detected


diffuser angle
photons arriving
15 degrees, 1e8 photons single flasher
photons detected
normalised photons detected
photons detected
photons detected

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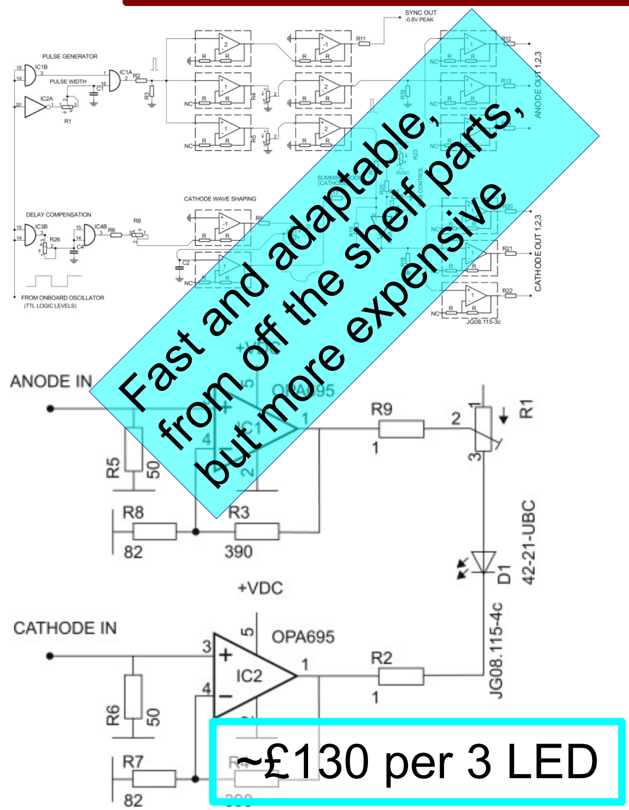
CHEC WP4.2: A number of LED driver and pulse shape circuits are under investigation.

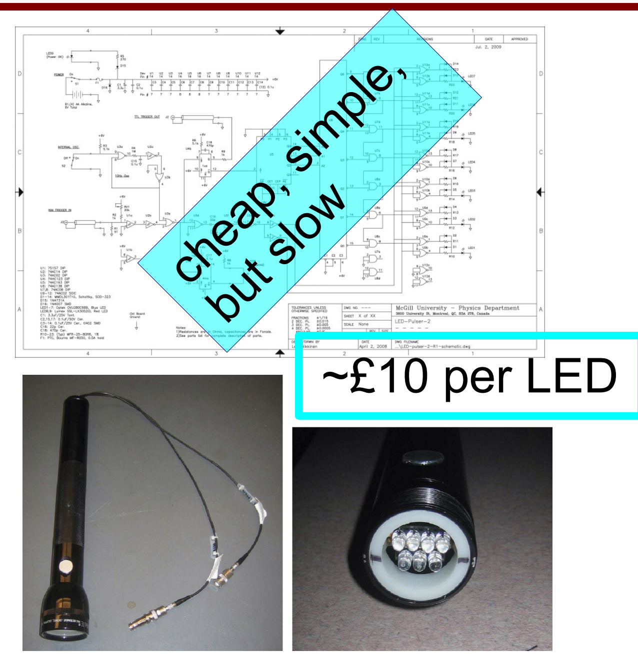
Requirement: The light pulse must have a maximum FWHM of 6ns, with a goal of 4ns.
Impacts: choice of light source/choice of driver circuit.

Requirement: The system must operate at rates in the range of 1 to 1000Hz (CHECK).
Impacts: choice of driver circuit & light source, Dependent on camera hardware & dacq.



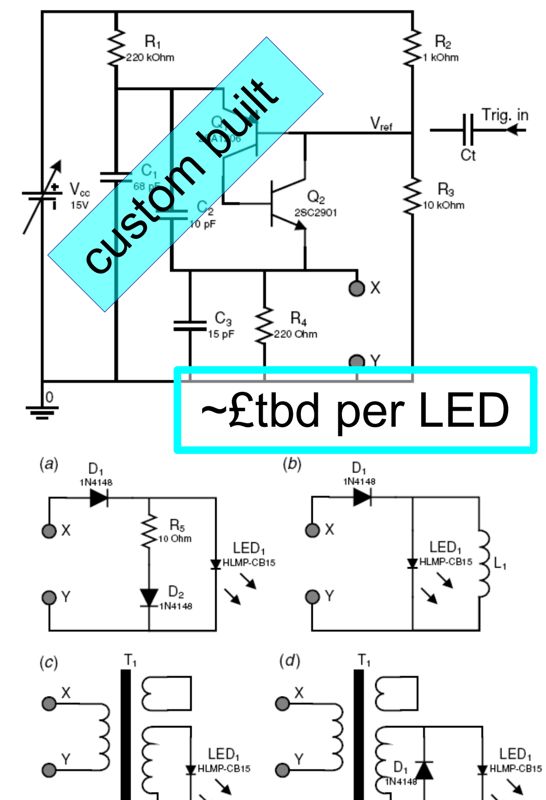
Ronchi et al. NIM A **599**, 243 (2009).

A bipolar technique with op-amps for high performance, stability and power. Will provide very fast pulses, but at a greater expense than simple transistor circuits.



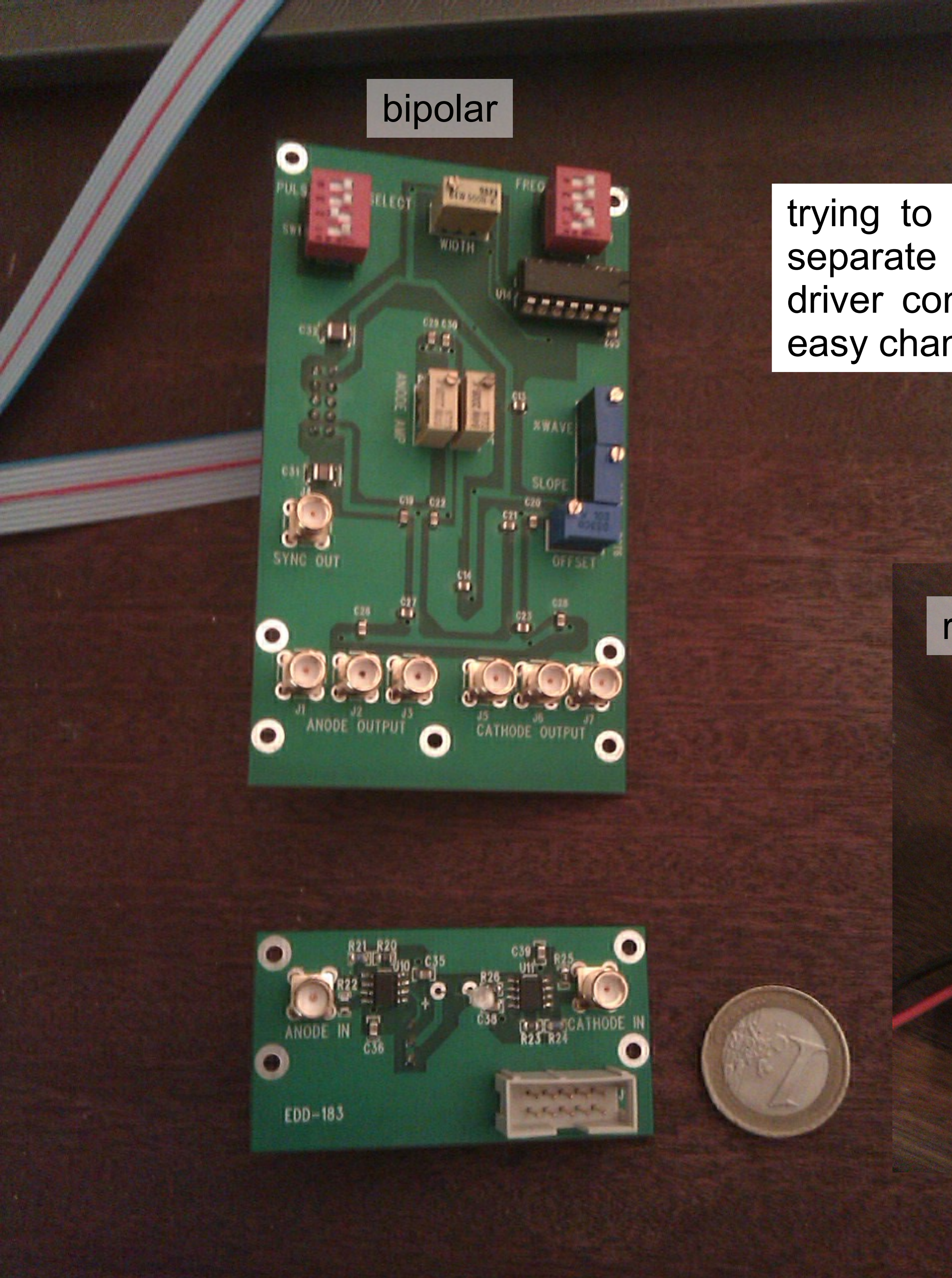
D. Hanna et al. NIM A **612**, 278 (2010).

A simple gate based on fast pulse based on fast pulse generator, light pulse width limited based on pulse generator & LED afterglow.

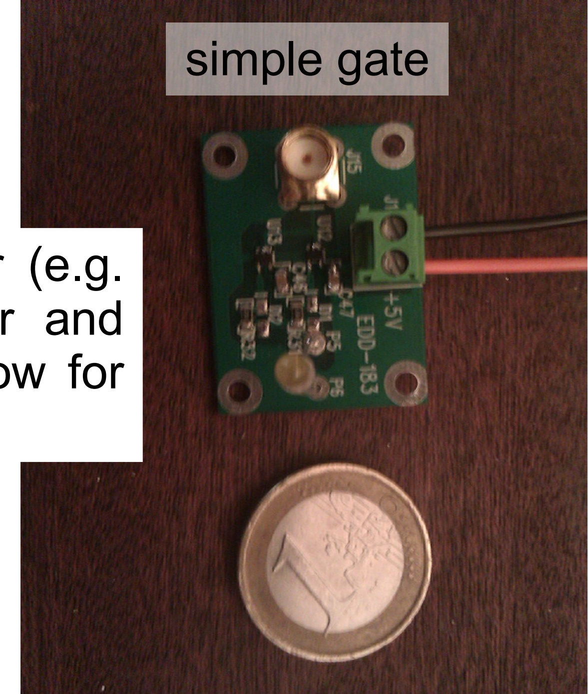


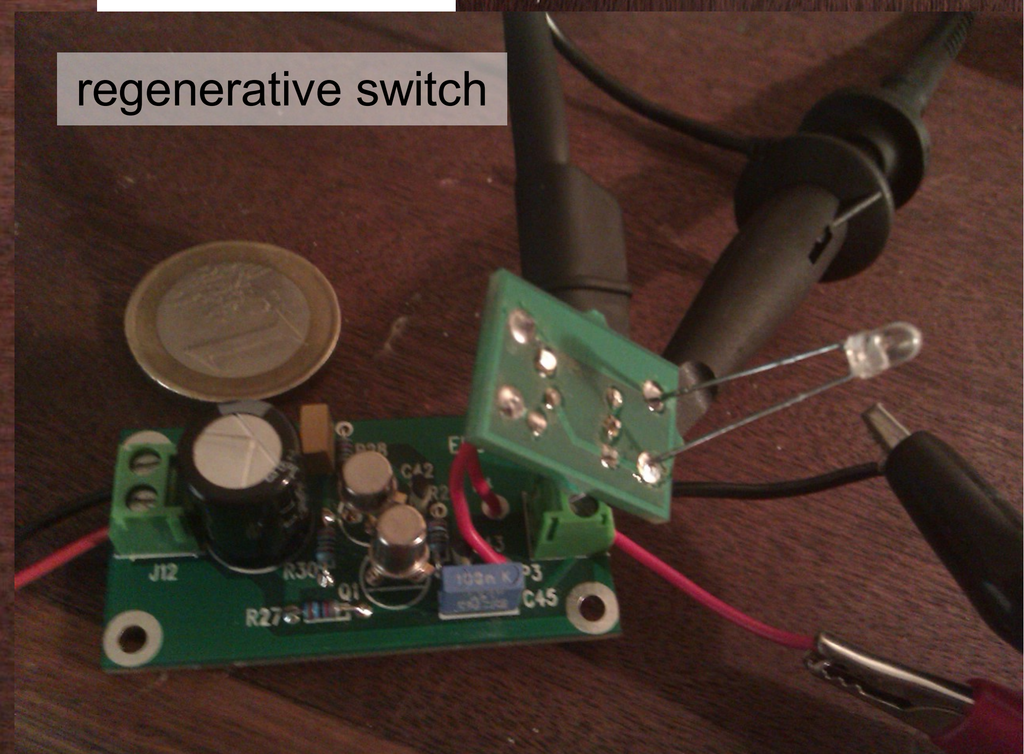
Veledar et al. MeScT **18**, 131 (2007).
[cf Aye et al. Proc. 28th ICRC 5, 2975 (2003).]

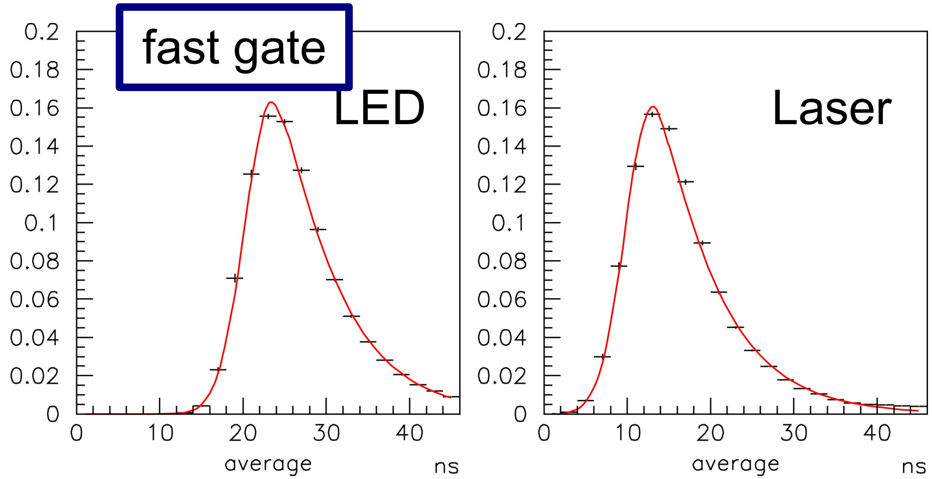
A transistor based regenerative switch, again get faster pulses, but requires custom built circuit that may not be easily reproducible in bulk.



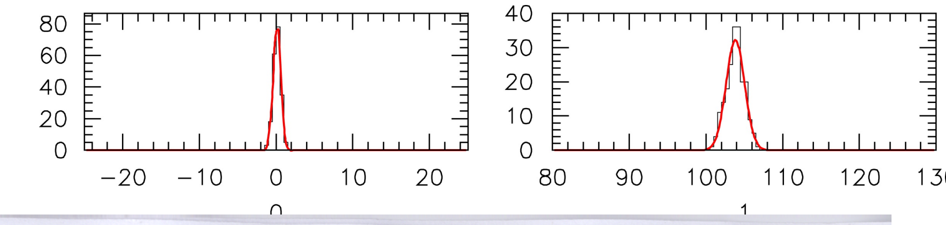
trying to keep it modular (e.g. separate pulse generator and driver components to allow for easy change/upgrade

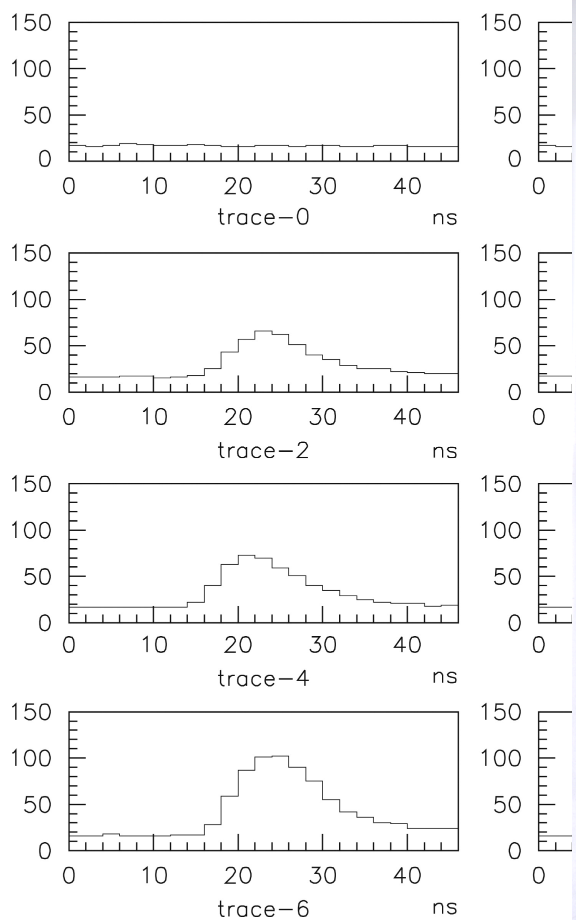


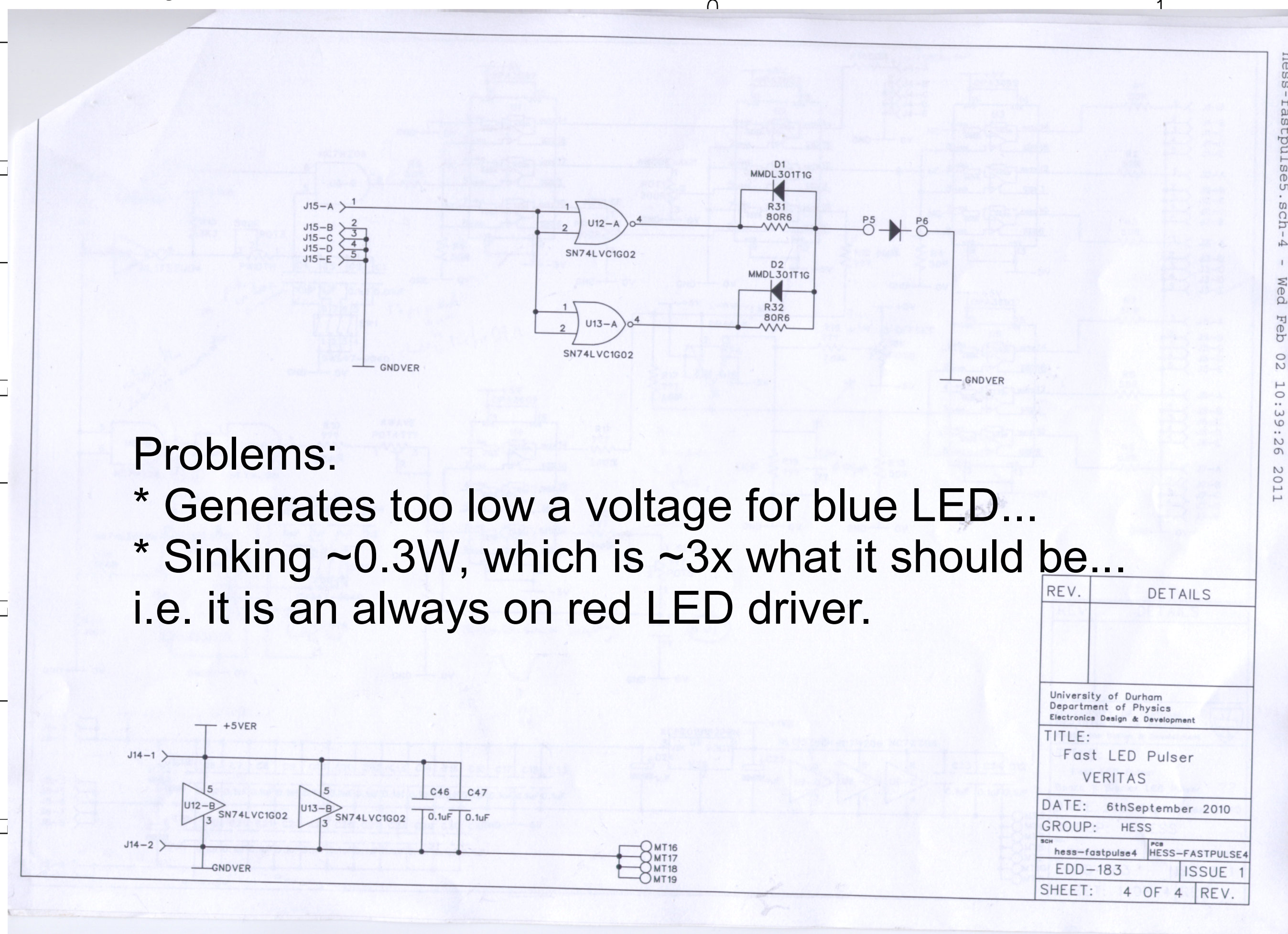


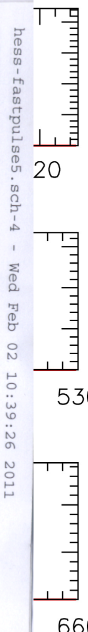


average pulse size

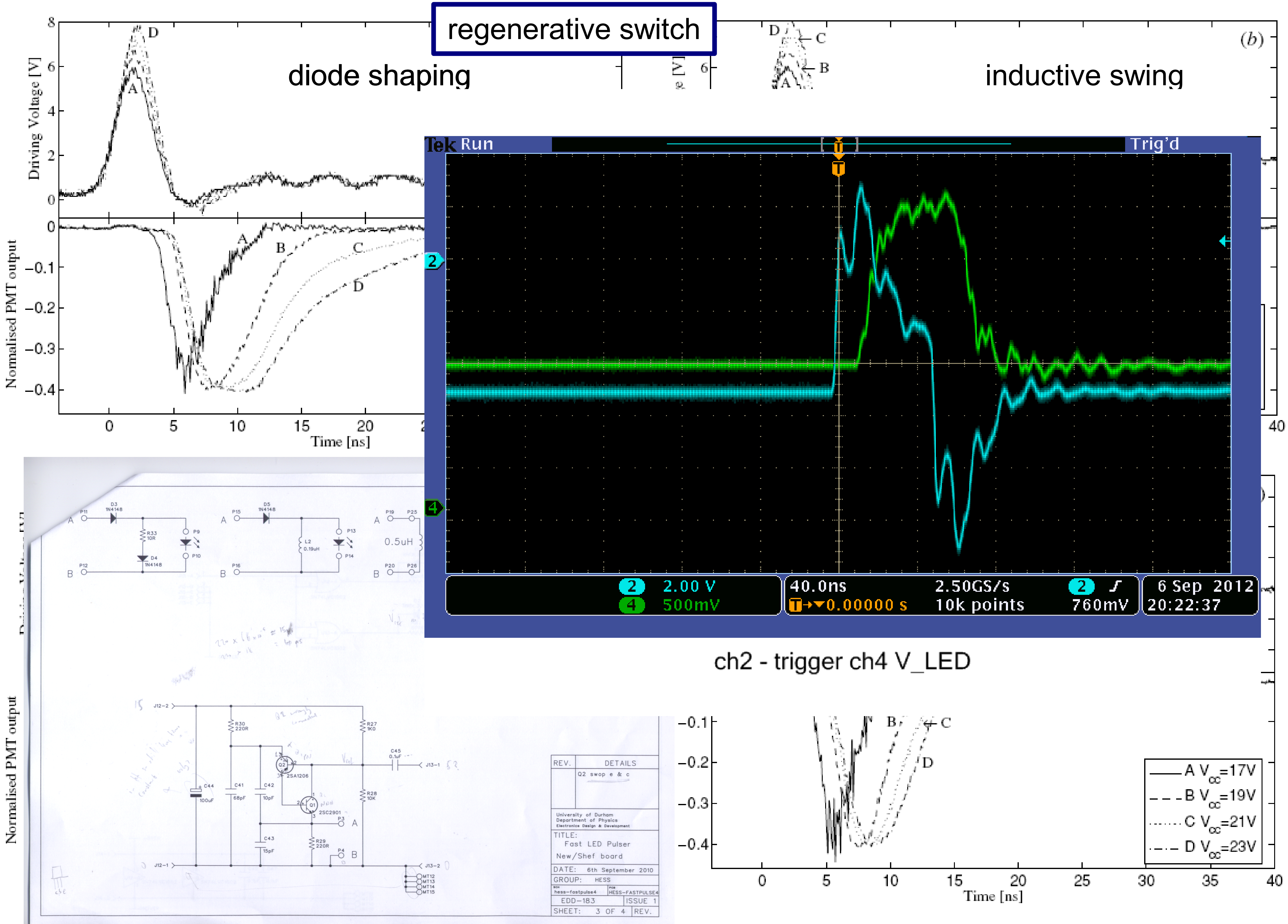


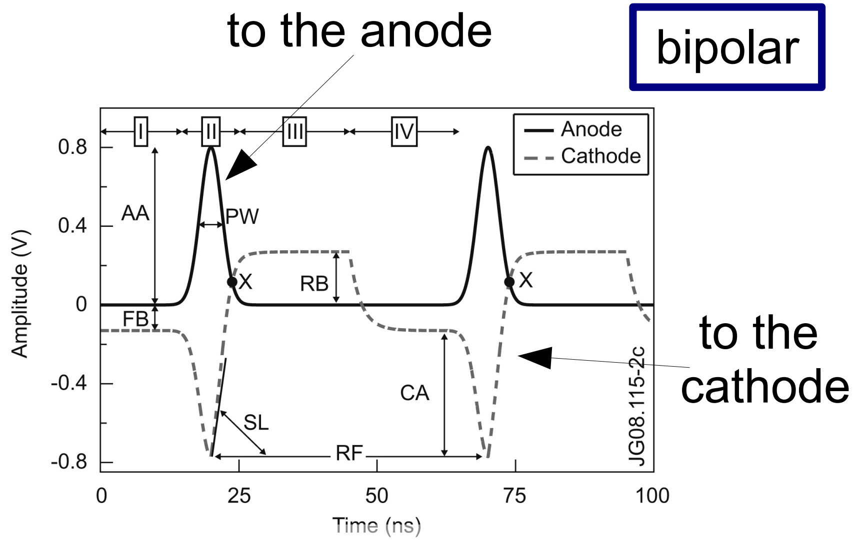


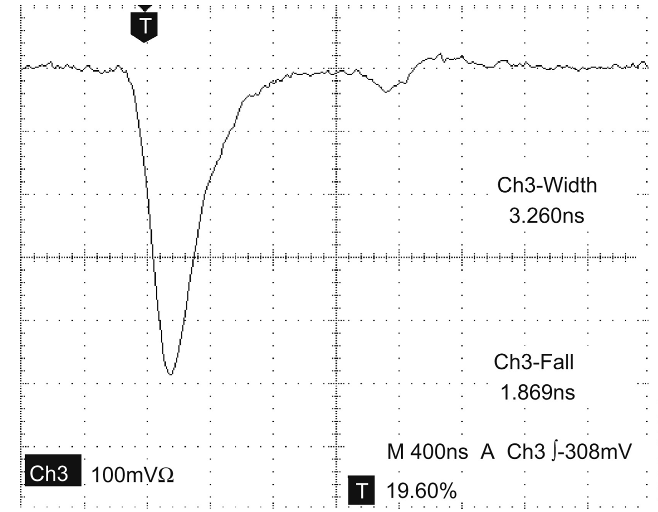




Problems:
* Generates too low a voltage for blue LED...
* Sinking ~0.3W, which is ~3x what it should be...
i.e. it is an always on red LED driver.


regenerative switch
diode shaping
inductive swing
Driving Voltage [V]
Normalised PMT output
Time [ns]
Tek Run
Trig'd
2.00 V
500mV
40.0ns
2.50GS/s
10k points
760mV
6 Sep 2012
20:22:37
ch2 - trigger ch4 V_LED
A V_{cc}=17V
B V_{cc}=19V
C V_{cc}=21V
D V_{cc}=23V
(b)
University of Durham
Department of Physics
Fast LED Pulser
New/Shef board
DATE: 6th September 2010
GROUP: HESS
EDD-183
ISSUE 1
SHEET: 3 OF 4

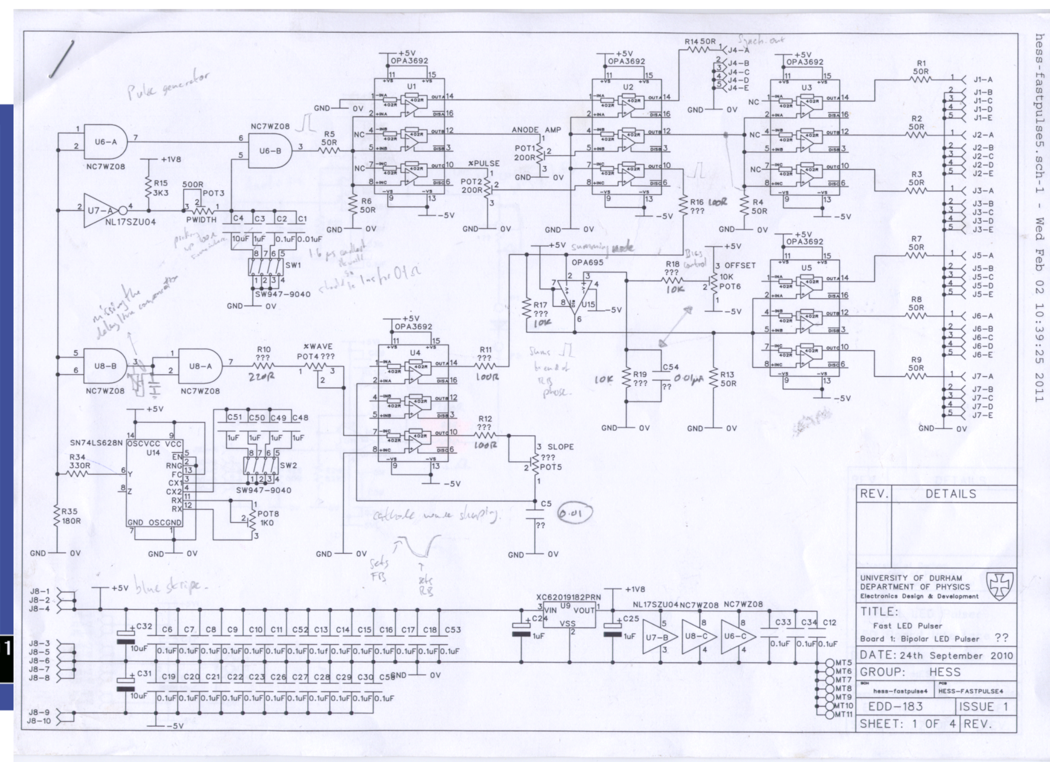




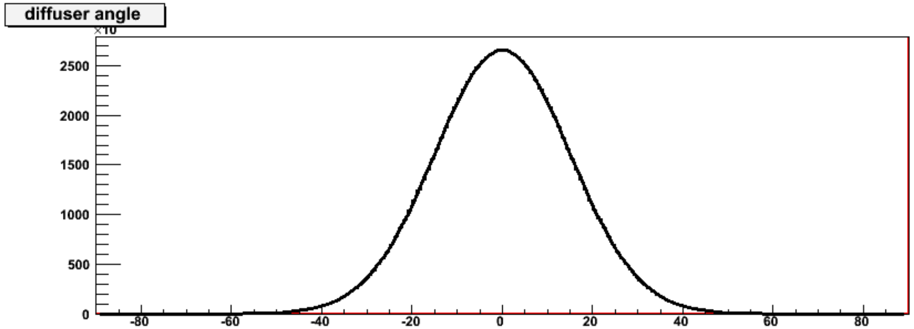
Phase I: weak foward bias (FB) prior to pulse to speed off to on transition
Phase II: enhance light yield through electric push-pull from both electrodes
Phase III: reverse bias for controlled depletion of electrical charge in junction
Phase IV: restore forward bias & repeat.

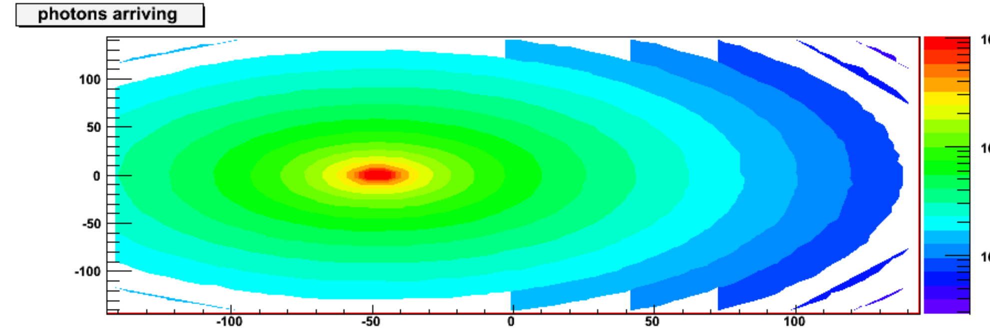
Ronchi et al.
NIM A **599**, 243 (2009).

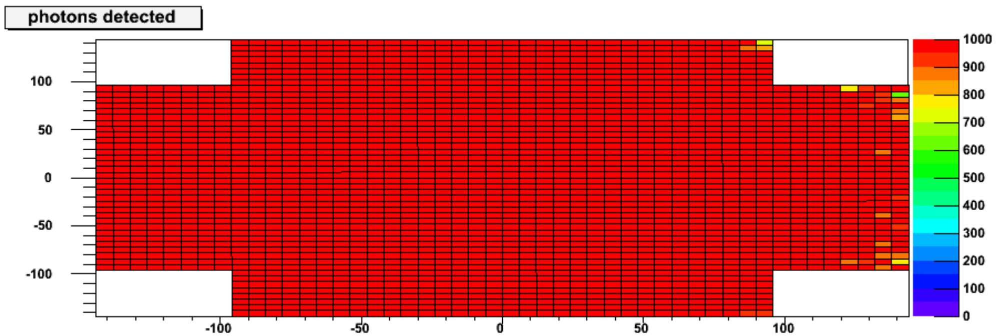
ch1 anode ch2 cathode ch4 trigger

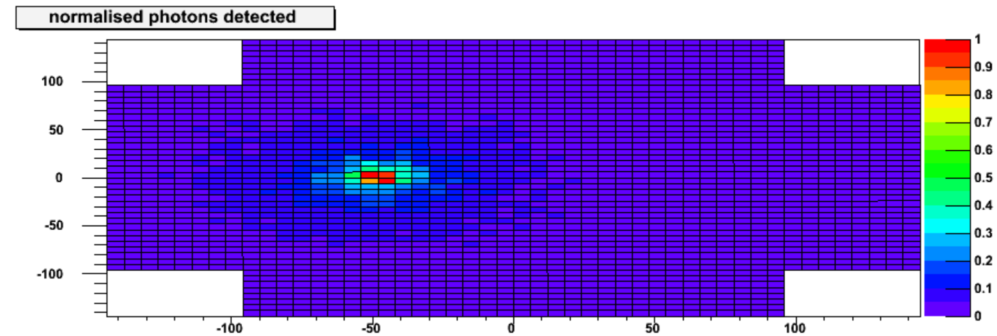


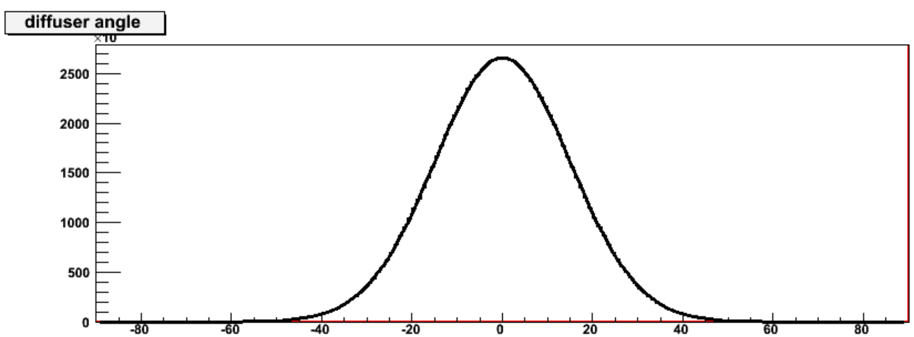
Extra slides

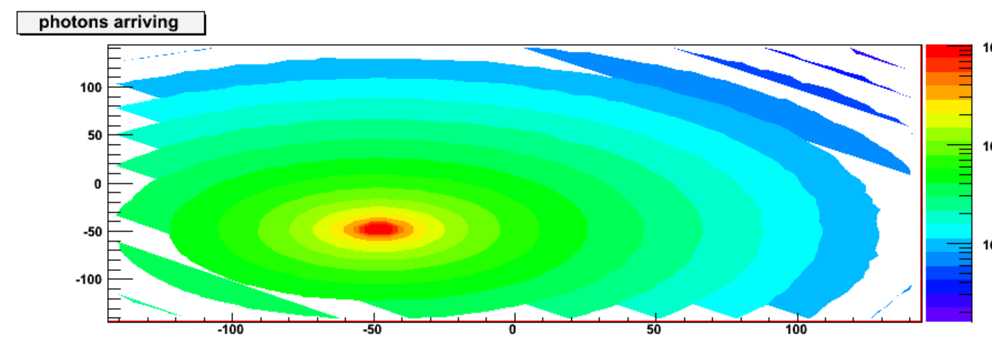

diffuser angle

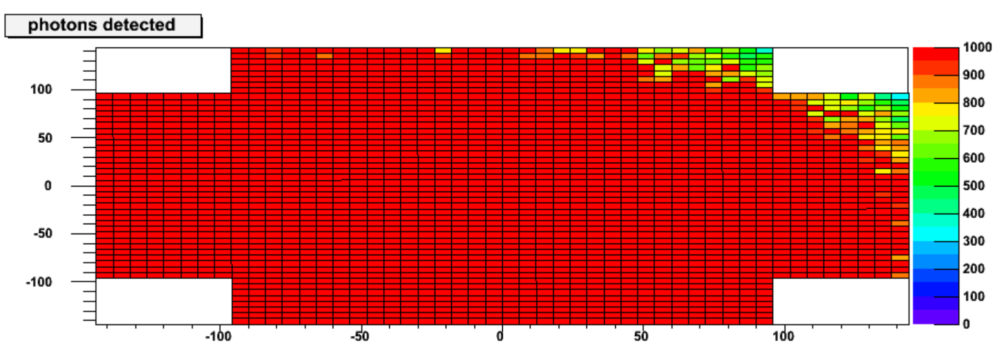

photons arriving

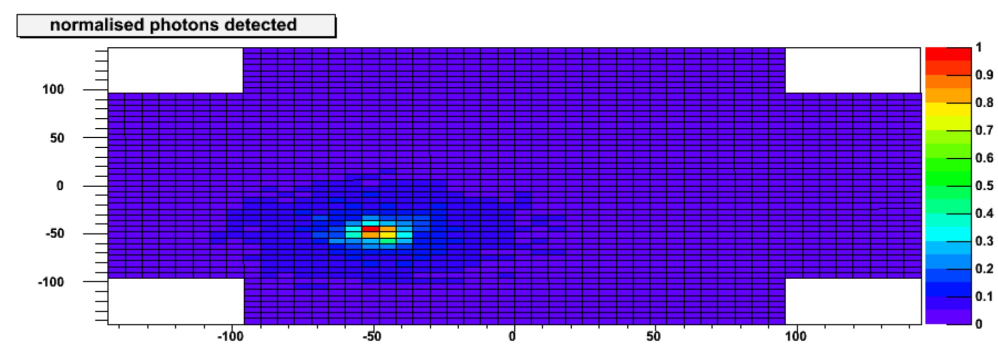

photons detected

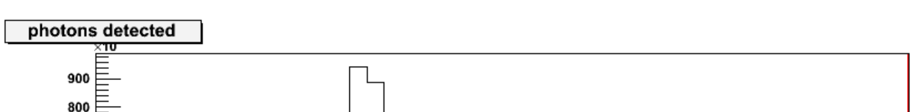

normalised photons detected

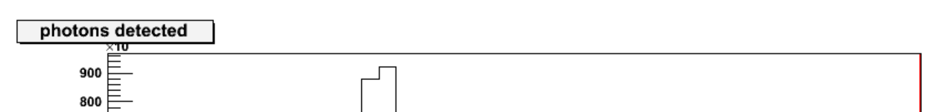

diffuser angle


photons arriving


photons detected


normalised photons detected


photons detected


photons detected

regenerative switch

Table 1. Timing results—as measured.

Circuit and curve	Time	Best—plot A Electrical time (ns)	Best—plot A Optical time (ns)	Worst—plot D Electrical time (ns)	Worst—plot D Optical time (ns)
6(*a*)	Rise	2.24	2.12	2.04	1.91
and	FWHM	3.45	3.81	3.56	13.90
8(*a*)	Fall	3.10	3.80	2.96	34.29
6(*b*)	Rise	2.04	1.75	2.07	1.85
and	FWHM	3.28	3.27	3.22	8.73
8(*b*)	Fall	2.37	2.23	2.05	9.62
6(*c*)	Rise	2.07	1.65	1.99	1.91
and	FWHM	3.79	3.14	3.80	4.36
8(*c*)	Fall	1.96	1.87	1.80	3.99
6(*d*)	Rise	3.07	1.85	3.01	2.00
and	FWHM	3.69	3.02	3.67	6.23
8(*d*)	Fall	1.88	2.21	1.81	5.97

Veledar et al. MeScT **18**, 131 (2007)